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Effect of building renovation on energy use and indoor environment: Comparison of simulations and measurements in six apartment buildings

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SUMMARY

Energy performance and the indoor environmental quality (IEQ) in three naturally ventilated original and three identical but renovated residential buildings were compared using actual measurements. Although the implemented energy saving measures had the potential to improve energy performance of the dwellings, they led to poorer indoor air quality (IAQ). Additional simulations revealed that a simple intervention, such as using exhaust systems in kitchens and bathrooms and at the same time keeping doors of rooms open, may improve the IAQ in retrofitted multifamily buildings.

PRACTICAL IMPLICATIONS

The results advocate the need for measures to improve indoor air quality as a part of residential energy renovation projects.

KEYWORDS

Retrofitting, Residential Building, Energy Performance, Indoor Air Quality, Ventilation model

1 INTRODUCTION

Most of the apartment buildings in Slovakia were built from 1945 to 1992. Many of these buildings do not fulfil current requirements on energy efficiency. Energy saving measures, such as envelope insulation and tighter windows are implemented (Panayiotou et al., 2010). The impact of such energy renovation on IEQ is rarely considered. The objective of the present study was to investigate the actual measured energy use of naturally ventilated residential buildings and its relationship with IEQ.

2 MATERIALS/METHODS

Three pairs of buildings were investigated. One building in each pair was renovated and the other one was in its original state. Energy use for heating was monitored in all six buildings during the entire heating season and the specific heat demand was calculated according to the National Building Code (2012). IEQ parameters (see Table 1) were measured during the winter in 50% of all apartments within each building. Evening and night-time data are presented to represent occupied periods. Occupants' satisfaction with IEQ in their apartments was investigated by using questionnaire survey. Additionally, dynamic building performance simulations were carried out using IDA-Indoor Climate and Energy software (EQUA Simulation AB, Sweden). CO₂ concentrations were simulated for one of the buildings before and after renovation using different alternatives of ventilation systems (no mechanical ventilation, constant volume and demand controlled ventilation).

3 RESULTS AND DISCUSSION

Table 1 compares the calculated specific heat demand, the measured energy performance and the measured IEQ in the original and the renovated buildings. Implementation of energy

saving measures reduced energy use for space heating by more than 30%. Although the energy performance of the buildings improved after renovation, higher CO₂ concentrations ($p \geq 0.05$), lower air exchange rates (AER; $p < 0.05$) and lower acceptability of air quality (ACC) ($p < 0.05$) were observed in the renovated dwellings compared to the original buildings in winter.

For one of the buildings we created simulation models of its original and renovated state. Results of the simulations confirmed that energy renovation without considering additional ventilation, which is often the common practice, may increase CO₂ concentrations in the apartments (Table 2). Adding standard air handling units in bedrooms, or, at the minimum, exhaust systems in kitchens and bathrooms while at the same time keeping internal doors open, may significantly improve IAQ in newly energy renovated residential buildings.

Table 1. Summary of the energy performance and night-time (20:30-6:30) averages of IEQ parameters in the original and the renovated residential buildings

Building pairs	Building condition	Energy performance					Indoor Environmental Quality*						
		Specific heat demand			Actual energy use for space heating		RH	T	CO ₂	AER**	ACC	Thermal Sens.	Thermal Accept.
		kWh/m ² .year	Energy class	Diff. (%)	kWh/m ² .year	Diff. (%)	(%)	(°C)	(ppm)	(h ⁻¹)	(-)	(-)	(-)
I	Original	136	D	57	96	53	49	21.4	1740	0.68	0.50	0	0.35
	Renovated	58	B		44		45	23.2	1930	0.44	0.06	2	0.30
II	Original	145	D	38	104	49	48	22.4	1320	0.82	0.49	1	0.67
	Renovated	90	C		53		47	23.1	1580	0.52	-0.02	2	0.38
III	Original	139	D	48	101	39	48	21.7	1060	0.97	0.71	1	0.58
	Renovated	71	B		62		47	21.8	1520	0.49	-0.04	2	0.17

*Each value is the grand mean obtained for all investigated apartments within the given building.

**The recommended minimum ventilation rate is 0.5 h⁻¹.

Table 2. Simulated night-time (20:30-6:30) averages of IEQ parameters in building pair I, and for the renovated building using various alternatives of ventilation systems

Building condition	Alternatives of ventilation system				Indoor Environmental Quality			
	Ventilation	System type	Location	Mech. air supply per year	CO ₂	T _{op}	T _{air}	RH
					(ppm)	(°C)	(°C)	(%)
Original	Natural vent	Opened windows in period 7:00-7:30 and 19:00-19:30.	Bedroom	0 kWh	1190	17.8	17.9	37
Renovated	Natural vent	Opened windows in period 7:00-7:30 and 19:00-19:30.	Bedroom	0 kWh	1520	20.3	20.4	33
Renovated	Air Handling Unit	Temperature and CO ₂ control	Bedroom	635 kWh	800	20.1	20.1	25
Renovated	Air Handling Unit	CO ₂ control	Bedroom	624 kWh	795	19.9	19.9	25
Renovated	Air Handling Unit	CAV Exhaust only; opened doors of room	Kitchen, bathroom	0 kWh	755	19.0	18.8	27

5 CONCLUSIONS

Envelope insulation and window replacement can decrease the energy use for heating by over 40% in multifamily dwellings in Central Europe, built mainly of concrete panels. Such basic energy renovation may however deteriorate the indoor air quality, unless at least simple measures are taken to achieve increased air exchange rates in the apartments.

6 REFERENCES

- G. P. Panayiotou, S. A. Kalogirou, G. a. Floride set al. 2010. The characteristics and the energy behaviour of the residential building stock of Cyprus in view of Directive 2002/91/EC. *Energy and Buildings*, Vol. 42, pp. 2083-2089.
- National Building Code. 2012. The Ministry of Transport, Construction and Regional Development SR 364/2012.